

Hazards and Uses of Prenatal Diagnostic X-Radiation

Lee C. Schussman, MD, and Lawrence J. Lutz, MD
Salt Lake City, Utah

Diagnostic x-ray studies during any stage of gestation have been shown to increase the risk of childhood cancer in the irradiated fetus. This study reviews those risks and examines the uses of pregnant abdomen and x-ray pelvimetry studies. The abdominal films appear to have provided useful and necessary information in the management of labors and deliveries; however, the x-ray pelvimetry results appear to have provided much less usable information. The predictive values of both positive and negative x-ray pelvimetry studies were low, .57 and .66, respectively. The predictive values were low for both vertex and breech presentations. The definite hazards of prenatal diagnostic radiation studies should be carefully weighed against their possible benefits.

There is substantial evidence that diagnostic x-radiation received by a woman at any time during pregnancy may be detrimental to the fetus. To discover the extent of knowledge of practicing clinicians regarding the hazards of x-ray examination during pregnancy, the authors surveyed a number of their colleagues (obstetricians, family physicians who practice obstetrics, and radiologists). All of those interviewed were familiar with the hazards to the fetus of pelvic x-radiation early

in pregnancy, but very few of these clinicians were familiar with the potential hazards associated with diagnostic pelvic radiation late in pregnancy.

There is controversy over the potential benefits vs risks of cancer induction associated with diagnostic pelvic x-radiation during pregnancy, and yet these procedures are being used with pregnant women. Thus, the purposes of this paper are (1) to call attention to the risks of diagnostic pelvic x-radiation at any gestational age, (2) to quantify the use of diagnostic x-ray examinations used during pregnancy at a major community hospital (a teaching site associated with the University of Utah), (3) to ascertain the clinical situations in which diagnostic radiation is used during pregnancy, and (4) to examine the degree to which the data derived from such x-ray examinations are actually used in the management of labors and deliveries.

From the Department of Family and Community Medicine, University of Utah College of Medicine, Salt Lake City, Utah. At the time this paper was written, Drs. Schussman and Lutz were Robert Wood Johnson Fellows, Department of Family and Community Medicine, Salt Lake City, Utah. Requests for reprints should be addressed to Dr. Lee C. Schussman, McKay-Dee Porter Family Practice Center, 3955 Harrison Boulevard, Ogden, UT 84403.

0094-3509/82/030473-08\$02.00
© 1982 Appleton-Century-Crofts

Radiation Hazards

Stewart and her co-workers^{1,2} were the first to observe the relationship between increased numbers of childhood malignancies and prenatal diagnostic radiation. They found an association between leukemia and prenatal diagnostic radiation which, although more pronounced for radiation occurring in the first five months of pregnancy, was present in every month throughout the pregnancy (including the ninth and tenth months). Based on their data, Stewart et al constructed a mathematical dose-response model. This model predicted that an x-ray dose of 1 rad* of total body x-ray delivered to the fetus shortly before birth could cause an excess of 5 deaths per 10,000 children secondary to radiation induced cancer.

Subsequent studies have also pointed to the association between diagnostic radiation late in pregnancy and the development of childhood leukemia. MacMahon³ studied over 700,000 children and found elevated rates of cancer mortality for the offspring of women who received x-radiation on the day of delivery, within one week of delivery, or at other times during the third trimester. Similarly, Graham et al⁴ and Diamond et al⁵ published data from large epidemiologic studies and also concluded that exposure to diagnostic radiation during first, second, or third trimesters was associated with an increased risk for the development of childhood leukemia. Results of all these studies indicated that the average relative risk for leukemia in x-irradiated vs nonirradiated children was 1.40,⁶ which represented an increased risk of 40 percent in the irradiated vs the nonirradiated children.

Of all diagnostic x-ray examinations done purposefully during pregnancy, 90 to 95 percent are either abdominal flat plate films or x-ray pelvimetry films.^{1,5,7} These two procedures make up nearly 100 percent of the x-ray doses received late in pregnancy, with other films (such as incidental chest or dental x-ray films) making up only a small percentage.

The specific amounts of radiation received by the fetus during diagnostic procedures has been

difficult to ascertain, but several investigators have estimated such dosages using wax models and interpolation from skin dosage data.^{8,9} Approximately 0.4 to 1.0 total body rads are delivered to the fetus per pelvic x-ray film, resulting in approximately 1 to 4 rads per x-ray pelvimetry study.^{2,10} These dosage figures and the calculations of Stewart et al would thus predict 5 to 20 excess deaths per 10,000 children who received x-ray pelvimetry exposure in utero. Leukemia risk in the general population is approximately one case in 3,000 children, and x-ray pelvimetry can thus increase this risk to approximately one case in 2,000 children.¹¹

Efficacy of Pelvimetry

Stating their concerns over the potential risks of x-ray pelvimetry, several authors have looked critically at the efficacy of this procedure. Joyce et al,¹² without stating precisely how they arrived at their conclusions, reported that x-ray pelvimetry did seem to aid obstetricians in breech deliveries but did not seem to help in vertex deliveries. Radiologists Russell and Richards¹³ found no differences in the overall pelvic sizes in women sent to them for pelvimetry compared with a control group of women, and those authors seriously questioned the overall value of doing x-ray pelvimetry. Kelly et al¹⁴ studied 67,000 deliveries and constructed a computer generated decision tree to try to assess the value of pelvimetry studies. Those authors observed a great lack of consistency among physicians in ordering or not ordering pelvimetries when confronted with similar labor situations. They also found that nearly one third of women whose pelvimetry was interpreted as normal still delivered via cesarean sections. Varner et al¹⁵ also studied the use of x-ray pelvimetry. They found that overall pelvic size as determined by x-ray pelvimetry had little relation to the type of delivery that actually occurred.

In light of both the hazards of pelvic radiation during pregnancy and the questionable efficacy of such examinations, a study analyzing the use of these x-ray tests was done.

*Rad: 100 ergs of energy absorbed per gram of tissue

Methods

Incidence of Prenatal Diagnostic Radiation

Data on all the x-ray studies intentionally performed on pregnant women at the McKay-Dee Hospital in Ogden, Utah, during 1970 and 1979 were obtained. The delivery room, radiology records, and hospital charts were examined. The names of all women who received x-ray pelvimetry or abdominal films during pregnancy in 1979 were obtained by hand search of the radiology department's log, and the numbers of such x-ray studies were then cross-validated using the hospital radiological billing data. The number of x-ray pelvimetries and pregnant abdominal films were also obtained for the year 1970 through use of the billing data. The total number of deliveries for 1970 and for 1979 were obtained from the obstetrical log book.

Abdominal Films

A sample of 25 percent of all pregnant women who received abdominal films in 1979 was collected for detailed analysis. The following data were obtained from each hospital record in this 25 percent sample: date of delivery, fetal heart tone status,* Apgar scores, type of delivery, parity, indication for the abdominal film, and results of the abdominal film. The extent to which the x-ray examination itself seemed necessary to gain information for appropriate case management and the extent to which the management of the patient was consistent with the results of the abdominal x-ray examination were both assessed.

X-Ray Pelvimetry Films

Hospital records of all women undergoing pelvimetry during 1971 were studied in detail, and the

following information was abstracted: specialty of physician, status of fetal heart tones, Apgar scores, infant's weight, type of delivery, parity, weight of largest previously delivered infant, maternal age, use of consultation, gestation (weeks), duration of labor prior to the time x-ray pelvimetry was obtained, status of the cervix at the time of pelvimetry, time of day at which pelvimetry was obtained, duration of labor after pelvimetry was obtained, clinical indication for pelvimetry, position of the infant, result of the pelvimetry, the use of oxytocin, and the course and management of the labor following pelvimetry.

The investigators first tabulated the situations in which pelvimetry had been used. Then, using the data listed above, the investigators independently made assessments to determine if each patient's management was consistent with the information obtained from the x-ray pelvimetry. These assessments were rated on a three-point scale. A rating of "consistent" was given if the management of the labor and delivery immediately subsequent to pelvimetry was consistent with the radiologists' interpretation of that pelvimetry film. This occurred, for example, if the radiologist concluded that a narrow pelvis was present based on the x-ray film and soon thereafter a cesarean section was performed. For a management decision diametrically opposed to the pelvimetry result, a rating of "inconsistent" was given, indicating that pelvimetry results did not seem to have been used in the management. Thus, if the radiology report concluded that a narrow pelvis was present, and the patient subsequently received oxytocin to augment uterine contractions, an "inconsistent" rating was given. A rating of "indeterminant" indicated that it was not possible to determine from the data in the chart whether the pelvimetry result had played a role in the immediate management.

Results

Abdominal Films

The annual number of abdominal x-ray examinations performed during pregnancy decreased

*Over 90 percent of all women in labor in this hospital routinely received fetal heart monitoring.

Table 1. Indications Stated in the Medical Record for X-Ray Pelvimetries, 1979

Indication	Mode of Delivery		
	Number	Vaginal	Section
Primiparous breech	20	10	10
Breech (multiparous)	8	6	2
Primiparous, unengaged at term	4	1	3
No reason ascertainable	4	2	2
Failure to progress in labor	3	2	1
Possible cephalopelvic disproportion	3	2	1
Premature rupture of amniotic sac	2	1	1
Difficult delivery	1	1	
History of bony pelvis trauma	1		1
Repeat cesarean section	1	1	
Total	47		

significantly from 105 in 1970 to 40 in 1979, 3.2 and 1.1 percent of all deliveries performed in those years, respectively. All abdominal films analyzed in the sample were ordered by the delivering physician in an effort to determine accurately the presenting fetal part, and all of the women were in active labor at the time the films were taken. Seventy percent of the films were taken in women who were believed to have breech presentations. In all the breech cases, the delivering physician stated in the chart that he needed to know the type of breech so that he could plan vaginal or cesarean section delivery. Of the abdominal films sampled, 20 percent involved possible shoulder presentations in which the delivering physician was unsure of the presenting part and needed documentation as to whether he was feeling a hand or a foot.

X-Ray Pelvimetry

There was no significant change in the incidences of x-ray pelvimetry studies between the years 1970 and 1979, with the proportion of deliveries involving x-ray pelvimetry being 2.0 and 1.4 percent in those years, respectively. Women who received x-ray pelvimetry ranged in age from 15 to 32 years, and 90 percent of them were at term (38 to 42 weeks). All but seven had fetal heart monitoring performed during the course of their labors

and deliveries, and 84 percent of these fetal heart tone patterns were normal (a rate that is identical to the rate for the general population of parturients at this hospital). X-ray pelvimetry was usually obtained early in the labor. Eighty-three percent of the x-ray pelvimetry films were obtained either prior to the onset of labor (preadmission or at admission) or within one to two hours after the onset of labor.

Breech presentations accounted for a majority of the cases in which x-ray pelvimetry was used, with 28 (60 percent) of the 47 x-ray pelvimetry studies performed on breech parturients.

Table 1 displays all of the clinical indications given in the medical records for x-ray pelvimetries done during 1979; also displayed are the types of deliveries that eventuated. The most common stated indication for x-ray pelvimetry was that of a primiparous breech. Of the 20 women who were primiparous with breech presentations receiving x-ray pelvimetry, 10 were delivered vaginally, and 10 were delivered by cesarean section. Since primiparous breech deliveries made up the largest single indication, the results for the primiparous breech deliveries specifically are discussed in more detail below.

The x-ray pelvimetry results can be divided into the three major categories of normal, narrowed, or indeterminate, as shown in Table 2. There were 27 pelvimetries interpreted by the radiologists as

Table 2. X-Ray Pelvimetry Results and Related Delivery Types and Apgar Scores (n=47)

X-Ray Pelvimetry Results	Type of Delivery			Apgar Score <7		
		No.	%	No.	%	
Within normal limits (n=27)	Vaginal	18	67	1 min	10	55
	Cesarean section	9	33	5 min	3	17
Narrowed (n=7)	Vaginal*	3	43	1 min	4	44
	Cesarean section	4	57	5 min	1	11
Uninterpretable or borderline (n=11)	Vaginal**	6	55	1 min	2	33
	Cesarean section	5	45	5 min	1	16
No results on chart (n=2)	Vaginal	0		1 min	3	40
	Cesarean section	2	100	5 min	0	
				1 min	1	50
				5 min	1	50

*All three received oxytocin (Pitocin)
 **Three of five received oxytocin (Pitocin)
 †Five of five received oxytocin (Pitocin) and underwent cesarean section after changes in fetal heart tones or failure to progress

“within normal limits,” 7 pelvimetries interpreted as “narrowed,” 11 as either “borderline” or “uninterpretable” (because of failure of the radiograph to display prominent bony landmarks), and 2 cases which had no pelvimetry results recorded in either the delivering physician’s notes or a radiologist’s report.

Of the 27 parturients whose x-ray pelvimetries were interpreted as normal, 18 did have vaginal deliveries (67 percent) but 9 needed delivery by cesarean section (33 percent). The number of low (less than 7) Apgar scores of the infants delivered via cesarean section vs those delivered vaginally did not differ in this normal pelvimetry group.

Seven of the x-ray pelvimetries were reported as narrowed. Four of these women underwent immediate cesarean section, but the other three women received oxytocin (Pitocin) and eventually had vaginal deliveries.

Eleven of the 47 x-ray pelvimetry reports were either uninterpretable or borderline. Of these, five women received Pitocin but because of subse-

quent changes in the fetal heart tones or failure to progress, eventually had cesarean sections.

The predictive values for x-ray pelvimetry in predicting the necessity for a cesarean section were calculated and are displayed in Table 3. The predictive values of both positive (narrowed) and negative (adequate) x-ray pelvimetry tests are low, .57 and .66, respectively. Thus, of the women whose x-ray pelvimetry results indicated pelvic narrowing, only about one half were delivered by cesarean section; of those women whose x-ray pelvimetry results were normal, one third still eventually required a cesarean section. Failure to progress in labor and/or pathologic fetal heart patterns often seemed to precipitate the decision to perform a cesarean section regardless of the preceding x-ray pelvimetry results.

Twenty-eight percent of the labors and deliveries were managed in ways diametrically opposed to the management that would have been expected based upon the outcome of the x-ray pelvimetry study. Also, in an additional 12 cases (25 percent),

Table 3. Predictive Values of X-Ray Pelvimetry Results (in Predicting Cesarean Sections)			
X-Ray Pelvimetry Result	Mode of Delivery		
	Section	Vaginal	Total
Positive test (narrowed on pelvimetry)	4	3	7
Negative test (normal on pelvimetry)	9	18	27
Total	13	21	34
Sensitivity of x-ray pelvimetry (4 of 13)		.31	
Specificity of x-ray pelvimetry (18 of 21)		.86	
Predictive value of a positive test (4 of 7)		.57	
Predictive value of a negative test (18 of 27)		.66	

it was not possible to tell if the management was consistent with the x-ray pelvimetries. In 11 of these 12 cases, the x-ray pelvimetry results were either borderline or uninterpretable. Thus, in only 47 percent of the labors was the obstetrical management immediately following the x-ray pelvimetry clearly consistent with the results of that pelvimetry.

Breech Deliveries

Breech deliveries were examined in detail separately, and these results are displayed in Table 4. Regardless of the x-ray pelvimetry results, the ability of the x-ray pelvimetry to predict the need for cesarean section was low. For example, for primiparous breech deliveries, whether the x-ray pelvimetry result was normal, narrowed, or borderline, exactly 50 percent of all deliveries in every result category were vaginal and 50 percent were by cesarean section. For multiparous breech deliveries, only one x-ray pelvimetry was reported as narrowed; nevertheless, that baby was delivered vaginally. For multiparous breech deliveries with normal x-ray pelvimetry results, 30 percent still needed cesarean section; of those who were delivered vaginally, all had low Apgar scores.

Primiparous breech deliveries constituted 20 of

the 47 cases in which x-ray pelvimetry was performed. Apgar scores and types of delivery for all of the primiparous breech deliveries during 1979 were collected. There was a total of 3,255 deliveries in 1979, and of this total, 43 (1.4 percent) were primiparous breech deliveries. There were no significant differences in the cesarean section rates for primiparous breeches in women who did or did not receive pelvimetry. Further, as Table 5 displays, among all the primiparous breech infants, there were no significant differences in the Apgar scores between vaginally delivered or cesarean section delivered infants. There were also no significant differences in the Apgar scores of the primiparous breech infants whose mothers received x-ray pelvimetry when compared to those whose mothers did not receive x-ray pelvimetry.

Discussion

Paralleling the observed decrease of usage of abdominal films was a concomitant increase in ultrasound procedures, which have probably replaced the abdominal x-ray examination. Many of the 105 abdominal x-ray examinations in 1970

Table 4. Breech Deliveries: X-Ray Pelvimetry Results, Related Delivery Types, and Apgar Scores (n=20)

	Mode of Delivery	No.	Number of 1-Minute Apgars <7
Nonprimiparous breech			
Normal (n=7)	Cesarean section	2	0
	Vaginal	5	5
Narrowed (n=1)	Cesarean section	0	
	Vaginal	1	1
Borderline or uninterpretable (n=0)			
Primiparous breeches			
Normal (n=12)	Cesarean section	6	4
	Vaginal	6	2
Narrowed (n=2)	Cesarean section	1	0
	Vaginal	1	1
Borderline or uninterpretable (n=6)	Cesarean section	3	1
	Vaginal	3	0

Table 5. Apgar Scores and Types of Deliveries for Primiparous Breech Deliveries, 1979

	1-Minute Apgar Score <7		5-Minute Apgar Score <7		Total
	No.	%	No.	%	
All deliveries (n=43)					
Vaginal	10	40	6	24	25
Cesarean section	7	39	2	11	18
					43
Deliveries receiving pelvimetry (n=20)					
Vaginal	6	60	2	20	10
Cesarean section	4	40	1	10	10
					20

were done to assess fetal age, to determine the presence of a multiple gestation, or to determine the position of the placenta. These same factors, in addition to pregnancy diagnoses, were the clinical indications given for many of the diagnostic ultra-

sound procedures performed since its use was initiated in the mid-1970s.

The clinical settings of the abdominal films (all taken during labor to determine the presenting fetal part) seemed to justify their use, as there was

no other modality then available to ascertain quickly and with certainty this information. The results of the abdominal films were, in all cases, consistent with subsequent management of labor and delivery.

The extent to which x-ray pelvimetry results were used in the management of labor and delivery was much less than that observed for abdominal films. Analyses of the results of the pelvimetry x-rays revealed that one third of the women whose x-ray studies were normal, still required a cesarean section for delivery. Also, one half of the women with abnormally narrow pelvises, as identified by the radiologists' interpretation of the x-ray pelvimetry, still received trials of labor following pelvimetry. Overall, in over 25 percent of the cases the management of the labor was diametrically opposed to the management that would have been indicated from the outcome of the pelvimetry studies; in an additional 25 percent of cases, the x-ray pelvimetry result was borderline or uninterpretable. One might thus assume that, at best, x-ray pelvimetry played a role in the physician's decision making process in less than 50 percent of the cases in which it was used.

It should be noted that the incidence of pelvimetries performed at the McKay-Dee Hospital is quite low, near the 2 percent rate recommended by the American College of Obstetrics and Gynecology.¹⁵ At many university and community hospitals the pelvimetry incidences are reported to be much higher, between 12 percent and 40 percent.^{11,15} The relatively low incidence of use of pelvimetry might logically be expected to result in high predictive values. Despite the selective use, however, the predictive values of pelvimetry were still quite low. It seems apparent that the delivering physicians relied on information other than the pelvimetry outcomes to make most of their labor and delivery management decisions. It appears that the clinical parameters of failure to progress in labor or of abnormal fetal heart tone patterns played major roles in labor and delivery management decisions and that x-ray pelvimetry results played a very minor role.

As with vertex deliveries, in breech deliveries the x-ray pelvimetry results predicted poorly the need for cesarean section. For example, one half of the primiparous breech presentations with normal x-ray pelvimetry results still needed cesarean sections. It is even possible that the x-ray pelvime-

try results may have been falsely reassuring; for in multiparous breeches with normal x-ray pelvimetry results, all of those infants delivered vaginally had low 1-minute Apgar scores.

In view of the widely accepted hazards of diagnostic x-ray examinations in pregnancy, and considering the equivocal benefits of obtaining x-ray pelvimetry, this study adds further evidence to the growing opinion that with vertex deliveries, and possibly even with breech deliveries, x-ray pelvimetry provides little clinically useful information. Physicians should be aware of these high risk-benefit ratios before ordering such x-ray procedures for their pregnant patients.

References

1. Stewart A, Webb J, Hewitt D: A survey of childhood malignancies. *Br Med J* 1:1495, 1958
2. Stewart A, Kneale GW: Radiation dose effects in relation to obstetric x-rays and childhood cancers. *Lancet* 1: 1185, 1970
3. MacMahon B: Prenatal x-ray exposure and childhood cancer. *J Natl Cancer Inst* 28:1173, 1962
4. Graham S, Levin ML, Lilienfeld AM, et al: Preconception, intrauterine, and postnatal irradiation as related to leukemia. *Natl Cancer Inst Monogr* 19:347, 1966
5. Diamond EL, Schmerler H, Lilienfeld AM: The relationship of intrauterine radiation to subsequent mortality and development of leukemia in children. *Am J Epidemiol* 97:283, 1973
6. MacMahon B, Hutchinson GB: Prenatal x-ray and childhood cancer: A review. *Acta Unio Int Contra Cancrum* 20:1172, 1964
7. Dales LG, Ury HK, Friedman GD, et al: A study of time trends in maternal-fetal x-ray exposure. *Am J Epidemiol* 106:362, 1977
8. Reekie D, Davison M, Davidson JK: The radiation hazard in radiography of the female abdomen and pelvis. *Br J Radiol* 40:849, 1967
9. Matthews JC, Miller H: Radiation hazards from diagnostic radiology: A repeat survey over a small area. *Br J Radiol* 42:814, 1969
10. Jablon S, Kato H: Childhood cancer in relation to prenatal exposure to atomic-bomb radiation. *Lancet* 2: 1000, 1970
11. Kokenhour N: Report of the Utah PSRO review of pelvimetry usage. Presented to medical staff, McKay-Dee Hospital, Ogden, Utah, March, 1981
12. Joyce DN, Giwa-Osagie F, Stevenson GW: Role of pelvimetry in active management of labour. *Br Med J* 4: 505, 1975
13. Russell JGB, Richards B: A review of pelvimetry data. *Br J Radiol* 44:780, 1971
14. Kelly KM, Madden DA, Arcaese JS, et al: The utilization and efficacy of pelvimetry. *Am J Roentgenol* 125:66, 1975
15. Varner MW, Cruikshank DP, Laube DW, et al: X-ray pelvimetry in clinical obstetrics. *Obstet Gynecol* 56:296, 1980